

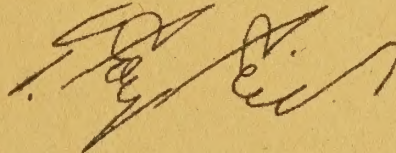
UNITED STATES DEPARTMENT OF AGRICULTURE
Office of Personnel
Washington 25, D. C.

June 10, 1947

To: Heads of Department Agencies
From: T. Roy Reid, Director of Personnel
Subject: Safety Manual for Chemical Laboratories

The Department Safety Council has recommended that the attached Safety Manual which was issued by the bureau of Agricultural and Industrial Chemistry of the Agricultural Research Administration, be made available to all Department agencies that operate chemical laboratories or who use chemicals in their operations.

Arrangements have been made with the Photographic and Duplicating Services Division of the Office of Plant and Operations so that each agency may requisition the number of copies they may need for distribution.



Attachment

JUL 24 1947

SAFETY MANUAL

FOR EMPLOYEES OF THE
BUREAU OF AGRICULTURAL AND INDUSTRIAL CHEMISTRY
AGRICULTURAL RESEARCH ADMINISTRATION
UNITED STATES DEPARTMENT OF AGRICULTURE

This Manual was prepared by the Safety Committees of the four Regional Research Laboratories in cooperation with the Technical Staff of the Chief of the Bureau of Agricultural and Industrial Chemistry. It is based on the experience of the Bureau in the development of safety measures for accident prevention in chemical laboratories, pilot plants, chemical storerooms and mechanical shops.

TABLE OF CONTENTS

	PAGE
GENERAL REMARKS.....	1
CHEMICALS.....	2
STORAGE AND HANDLING.....	2
DISPOSAL.....	3
HAZARDOUS CHEMICALS.....	4
FUMIGANTS.....	8
GLASSWARE AND GLASS APPARATUS.....	9
VACUUM SYSTEMS.....	10
PRESSURE REACTIONS AND PRESSURE EQUIPMENT.....	11
HIGH PRESSURE TECHNIQUE.....	11
COMPRESSED GAS CONTAINERS.....	13
FLAMMABLE MATERIALS.....	14
ELECTRICAL INSTALLATIONS.....	16
PROCESS EQUIPMENT.....	16
MISCELLANEOUS LABORATORY AND PILOT PLANT TECHNIQUE.....	17
MECHANICAL AND SHOP EQUIPMENT.....	19
GENERAL PRECAUTIONS.....	19
SAFE PRACTICES FOR SPECIFIC MACHINES.....	20
CARE OF MACHINES.....	23
CARE OF TOOLS.....	23
HANDLING MATERIAL.....	24
HOISTING AND MOVING OF EQUIPMENT.....	24
HOUSEKEEPING.....	25
OFFICE AND MISCELLANEOUS HAZARDS.....	25
PROTECTIVE EQUIPMENT FOR PERSONNEL.....	26

GENERAL REMARKS

The instructions in this manual are for the protection of you and your fellow employees. They are intended to show how accidents can be avoided. Your fullest cooperation in familiarizing yourself with and following these instructions is solicited in order that further progress can be made in preventing accidents and injuries.

These instructions cover not only the usual hazards encountered in the laboratory, the pilot plant, the chemical storeroom and the shops, but also some of the less common hazards that have been reported in the chemical literature, or have been experienced by members of the staff. Theoretically, it may be said that all accidents are avoidable. Practically, we recognize two major types of accidents. First, those which would not have happened had adequate care been exercised by the operator - the majority of accidents are of this kind; second, accidents caused by unforeseen failure of materials of construction or deviation of reactions from the expected course. Experience has shown that in the performance of all laboratory operations there is usually a best way, which is also the safest. Any potentially hazardous operation should always be conducted with maximum protection. Even though such an operation has been repeated a number of times without mishap, vigilance should not be relaxed or any of the safeguards removed.

In case of doubt regarding any operation, a person carrying out the operation for the first time, or having but little laboratory experience, should first consult with more experienced members of the staff. Under no circumstances other than emergencies should apparatus or equipment in laboratories other than your own ever be used without the knowledge and consent of the person immediately in charge. The most simple equipment may be a serious hazard in the hands of the inexperienced.

Good housekeeping is one of the most important factors in accident prevention, and it should be maintained to the fullest extent.

Operators should be familiar with and use, whenever necessary, personal protective equipment such as gloves, goggles, aprons, respirators, gas masks, fire blankets, and safety showers.

"Horseplay" and "stunt experiments" are dangerous and should not be indulged in.

Where unusual risk is involved, the number of individuals present should be kept at a minimum, but in no case should the minimum be less than two persons.

Doors that would have to be used in case of emergency must not be locked or blocked.

The responsibility for preventing accidents extends from the top of the organization all the way down to the individual worker. Section or group leaders must see that workers under their supervision are informed of hazards which they may encounter and of safety precautions and proper techniques to be used. No person or group should be entrusted with an operation beyond his or their capabilities. It is the obligation of each worker

who is the chief loser if hurt to follow the safety instructions that have been prepared and are pertinent to his work. Nature provided us with only one pair of eyes, hands, and feet, and they were meant to last a lifetime.

Although it is essential that a concerted and organized effort on a continuing basis be made to prevent accidents, it is also vitally important that procedures and means be established for prompt and effective action when a fire or explosion occurs, or an employee is injured. This will involve the transmission of a fire alarm to the plant fire brigade and, when necessary, to the city fire department; the use of fire-fighting and safety equipment within the plant; the evacuation of employees from affected areas; the rescue of injured persons; the administration of first-aid; and, in case of serious injury, medical treatment and hospitalization at the earliest possible moment. Employees at each field laboratory or station should be well organized and properly trained through the medium of appropriate committees, squads, and designated leaders, to perform prescribed and assigned duties for safeguarding, to the fullest extent possible, persons and property against fires, explosions, and other accidents.

A suitable electrical system should also be installed in cold rooms and other hazardous enclosures by means of which an employee, trapped therein or otherwise in distress, can transmit simultaneously both an audible and a visual alarm to a designated receiving station within the plant.

CHEMICALS

Storage and Handling. - Chemicals in heavy containers should be stored on or near the floor in places where they are protected from colliding and falling objects.

Parts of chemical containers should not extend beyond shelving or cabinets.

Materials that react with dangerous effect should not be stored in close proximity to each other; for example, oxidizing agents should not be placed near combustible materials, and strong acids should not be stored in such a position that an undesirable reaction could occur, if the container breaks.

No chemicals in glass bottles should be stored near a source of heat. Allow sufficient space above liquids in bottles to take care of a considerable thermal expansion of the liquid.

Containers in which metallic sodium and potassium are stored under kerosene or similar liquids should be protected against evaporation of liquid.

Fuming nitric and sulphuric acids should be stored in cabinets provided with lead-lined trays.

Special care must be exercised to see that corrosive, deliquescent, and highly reactive chemicals are stored or transported in safe containers.

All bottles should be labelled distinctly. Protect labels with transparent tape or lacquer.

Always check labels before filling bottles from stock supply.

Substances in unlabeled bottles should never be used before being positively identified.

Testing of chemicals by smelling should be done with caution. Testing by taste should be avoided or conducted with even greater caution.

The use of sulphuric acid or concentrated alkali solutions in gas-washing bottles presents some hazard, since stoppage of the gas exit will build up pressure which may be suddenly released. Preferably, a suitable manometric safety valve should be placed in such lines.

Do not use elevators for the transportation of solidified or liquefied gases, such as carbon dioxide, ammonia, and sulphur dioxide, in Dewar flasks or beakers.

Do not use sulphuric acid baths for the determination of melting points or boiling points. When concentrated sulphuric acid is employed as a desiccant, the safest practice is to use only enough liquid to wet some surface such as glass wool, porous tile, etc.

Do not pour corrosive liquids, such as strong acids and alkalies, at or above the eye level without proper eye protection.

It is hazardous to carry or transport materials in large glass vessels in one's arms unless protected by a rack, canvas jacket, or other protective device. Large bottles should not be carried by their neck.

Magnesium perchlorate should not be used for the drying of organic materials.

Sealed glass ampoules containing corrosive or volatile liquids should be opened and handled in the following manner:

Chill the ampoule in an ice bath or in a low temperature refrigerator. Wrap the ampoule with a towel, leaving the tip of the glass neck exposed; make a scratch near the tip with a fine file or glass knife; rest the surface of the neck opposite the scratch on the edge of a hard support in the hood, with the neck pointing away from the operator; knock off the tip of the neck with a light, but sharp downward blow. For storage of the unused portion, the ampoule can be closed with a loose-fitting glass plug and rubber connector, or the material can be transferred to a small glass-stoppered bottle. Seldom, if ever, is it advisable to attempt to reseal the sample by fusing the glass neck. This can be done safely only with materials known to be nonflammable and nonexplosive.

Disposal. - To discard small quantities of acids and alkalies, they should be highly diluted with water and flushed down the sink. They should never be put into refuse containers. When diluting a strong acid or alkali, the acid or alkali should always be poured slowly into the water to avoid violent splashing which may occur if the water is poured into the strong chemicals.

Flammable liquids not miscible with water should be collected in tightly covered metal containers, preferably safety cans, and poured into an outside solvent-waste can for disposal by burning. They should never be poured into the drains or sewers. Accumulation of large quantities should be avoided by frequent collection and disposal. Those miscible with water may be poured down the drain if dissolved in at least 20 parts of water or treated in the same manner as the nonmiscible liquids.

Alkali-metal scrap should be placed immediately in benzene, kerosene or toluene. The containers should be kept tightly closed, and the accumulated deposits should be disposed of only by experienced chemists at frequent intervals.

Alkali peroxides should be dissolved carefully by adding a little at a time of the peroxide to a large volume of cold water. The solutions should be reduced or neutralized before being discarded.

Oxidizing chemicals in general should be reduced before being disposed of.

Dangerous chemicals or those suspected of being dangerous should be disposed of only by chemists. Cyanides and other materials capable of evolving poisonous gas should not be emptied into drains or sewers. Disposal of such materials should be left to the chemists in charge of the section.

Hazardous Chemicals - Chemicals that disturb normal physiology may be regarded as toxic. The fact that physiological effects are not immediately apparent is no indication that a chemical is harmless. Bodily absorption of toxic materials may occur by inhalation or by contact with the skin.

Do not mix strong oxidizing agents such as nitric and perchloric acids, nitrates, and perchlorates, with easily oxidizable materials such as sulphur, sulphides, and organic chemicals, without proper care and realization of the explosion hazard involved.

Have gas masks readily available and properly labeled. Where special gases such as ammonia or sulphur dioxide are a hazard, appropriately marked masks should be provided for the specific service.

Hoods should be used when evaporating acids and flammable liquids and when working with toxic and poisonous vapors or gases. Hoods should also be used for ash tests where fumes are given off, for decomposing chemicals by means of acids, for boiling solutions containing ammonia, hydrogen, sulphide, sulphur dioxide, etc., and for experimental work involving explosion hazards. For maximum safety it is essential that hoods be operated with the front windows in the closed position.

Every new chemical prepared in the laboratory should be considered a hazardous material until its properties have been determined. Detailed information on the toxicity of specific chemicals can often be obtained from the National Institute of Health, Bethesda, Maryland.

Following is a list of the more common hazardous chemicals that are used in laboratory work:

ACETAL - Caution must be exercised when working with old samples of acetal because of the possibility of an explosion. A report on such an explosion is given on page 1029 of the June 25, 1944 issue of Chemical and Engineering News, Vol. 22, No. 12. A specimen of diethylacetal which had been stored for an indeterminate period in amber glass and in complete darkness was being distilled. After collection of a considerable forerun that appeared to be alcohol, and at the time when acetal was just beginning to come over, an explosion of great violence occurred. It was not accompanied by flame and appeared to take place in the vapor phase, since the stillhead and condenser were shattered, but the flask remained intact.

ACRYLATES - Methyl and ethyl acrylate monomers should be stored in a cool, dark place. Without an inhibitor the monomers may be destroyed with explosive violence. The following table shows the time required for destruction of ethyl acrylate at various storage temperatures with and without an inhibitor. Other acrylate monomers behave similarly.

INHIBITOR	TEMPERATURE °F.	SHELF LIFE
1/4 PERCENT HYDROQUINONE	68-86	12 MOS
1/4 PERCENT HYDROQUINONE	68-122	4 MOS
1/4 PERCENT HYDROQUINONE	68-140	3 MOS.
NONE	176	7-1/2 HRS
NONE	158	20 HRS.
NONE	140	44 HRS.
NONE	122	116 HRS.
NONE	104	OVER 116 HRS.
NONE	32	OVER 5 MOS.

Not more than a two-month's supply of the monomer should be purchased. If sufficient monomer is in storage to last during the summer months, an additional 1/4 percent hydroquinone should be added.

ALUMINUM CHLORIDE should be considered as a potentially dangerous material. If moisture is present, sufficient decomposition to build up considerable pressure may result. If a bottle is to be opened after long standing, enclose it completely in a heavy towel.

AMMONIA forms an explosive compound with silver or mercury. It should never be placed in contact with such metals. An ammoniacal solution containing silver or mercury should not be permitted to dry, but should be acidified and discarded at the first opportunity.

ANILINE is a poison, and its fumes are readily absorbed, producing convulsions and death in case of large doses. The following precautions should be observed: Use only the minimum amount required at a time. Wash off immediately any spillage that may occur; use extreme care to avoid inhaling the fumes. Remove immediately any clothing saturated with aniline to avoid contact with skin.

BENZENE - While vapors of all aromatic compounds are more or less toxic, benzene vapors are particularly dangerous when inhaled. Great care should be taken in working with large quantities of benzene to avoid escape of the vapors into the surrounding atmosphere. Stills used for recovery of benzene should be located in a special room or space that is provided with sufficient ventilation to remove all vapors of benzene liberated.

BENZOYL PEROXIDE when dry, is easily ignited and is sensitive to shock. It will decompose spontaneously at temperatures above 50° C. It is desensitized by adding 20 percent water.

CARBON DISULFIDE- Because of extreme flammability and wide range of explosive limits of its vapors, carbon disulfide is one of the most hazardous flammable solvents used in the laboratory. Extreme care must be exercised at all times when handling. Vapors of carbon disulfide may be ignited by exposed steam pipes. The liquid may be ignited by static electricity when poured from one container into another. For safety, both containers should be grounded.

CHLORINATED HYDROCARBONS cause dermatitis and other body disorders on continual exposure, even in small amounts. They act not only as defatting agents on the skin, but are selectively absorbed by some organs of the body. Avoid continual contact with all such materials either on the skin or by breathing.

CHLORINE, BROMINE AND IODINE produce extremely poisonous vapors and should never be used except in a hood. Chemicals containing ammonia should not be mixed with chlorine or bromine, and those containing iodine or ammonia should not be mixed with chlorides, bromides or iodides in the presence of oxidizing agents. Extremely sensitive and dangerous nitrogen trichloride, bromide or iodide may be formed.

DIETHYLENE DIOXIDE (dicxar) is purported to be a poisonous compound having delayed action. This material should be handled cautiously and not inhaled. Condensation of distilled vapors should be done with water above 10° C. to prevent plugging of the condenser.

DIMETHYL SULFATE is an extremely reactive material, especially when it comes in contact with skin or mucous membrane. A very short time of contact will result in a painful burn, and sight will be impaired if it comes in contact with the eye and is not removed immediately. Inhalation of the vapors will cause a toxic effect which may be delayed but very severe. It should never be used in the open laboratory but always in a well ventilated hood.

DRY ICE - Do not handle with bare hands. It should never be stored in a container which can be accidentally stoppered.

HYDROGEN FLUORIDE is extremely corrosive to the skin and lungs. It should never be used without adequate protection against contact with skin or inhalation of vapors.

Hydrogen Peroxide - Great care must be used in handling solutions stronger than three percent because contact with the skin may cause severe burns.

Hydrogen Sulfide and Hydrogen Cyanide are dangerous gases and should be used only in a well ventilated hood. Solutions of cyanides should be labeled in a prominent manner and should not be allowed to remain on the laboratory table except when being used.

Mercury - Care should be exercised in handling mercury and any spills should be cleaned up at once. Traces of mercury left in crevices volatilize slowly and poison the atmosphere. Mercury should not be drawn into pipettes or other tubes by sucking with the mouth.

Nitric Acid may form explosive compounds when used to clean apparatus containing organic residues. It should be used as a cleaning agent only after careful consideration of the hazards involved.

Nitriles, especially the lower homologs, react similarly to hydrogen cyanide and should be handled under a hood. Acrylonitrile is a very active poison; a concentration of 270 p.p.m. in the air produces fatal results when inhaled.

Old Ether Stocks - All ethers tend to undergo auto oxidation in storage to form peroxides. These peroxides are relatively stable at room temperature and under dilution in the ether, but may decompose violently when the ether is evaporated. While any ether may form peroxides, diethyl and di-isopropyl ethers are unusually susceptible to this oxidation. The higher-boiling ethers are not so hazardous as the lower boiling members of the series because during evaporation the heat tends to destroy the peroxides. All old ether stocks should be tested before use. To test, shake a small portion of the ether with aqueous potassium iodide solution; the release of free iodine (starch test) indicates the presence of peroxides. To destroy the peroxides, add ferrous sulfate solution or sodium bisulfite until the potassium iodide test is negative. To prevent peroxide formation in ether, store in brown bottles or in a dark cabinet. Inhibitors such as diphenylamine, alpha-naphthol, hydroquinone or metallic copper may be added.

Perchlorates - The use of perchlorates should be avoided wherever possible. Only persons thoroughly familiar with the hazards involved should handle perchlorates. With dry alkyl halides perchlorates react to form free halogen acids and explosive quantities of perchloric acid. Silver perchlorate crystals are highly unstable. While perchloric acid of 70 percent strength may be boiled safely at approximately 200° C., contact of the boiling undiluted acid or hot vapor of perchloric acid with organic matter or even easily oxidized inorganic matter, such as compounds of trivalent antimony, will lead to serious explosions.

Phenol (carbolic acid) dissolved in organic solvents is readily absorbed into the blood stream with resulting serious or fatal poisoning. The antidote for an accidental spill is to wash all affected parts with ferric chloride in an alcohol solution. This antidote should be kept available in a laboratory using this material.

Phosgene is extremely dangerous because its symptoms are delayed four to eight hours when small but toxic amounts are inhaled.

Phosphorus - Great care should be exercised in handling white (or yellow) phosphorus because of its poisonous nature and extreme flammability. Since it ignites upon contact with air and must be stored under water, it is a dangerous material to store in a laboratory. It should not be allowed to come in contact with the skin.

Phosphorus Trichloride containing moisture may, under certain circumstances, form phosphine when heated, and explode violently.

Pyridine vapors are quite toxic.

Sulfonyl Chlorides made by chlorination of mercaptans and related compounds have been known to explode violently during preparation.

The following publications give further information on hazardous chemicals:

"Toxicology of Gases and Vapors," International Critical Tables, Vol. 2, pp. 318-321.

Chemical Engineers' Handbook, edited by John H. Perry, 2nd edition, pp. 2935-2950.

"Industrial Poisoning by Aromatic Compounds," by D. H. Killeffer, Journal of Industrial and Engineering Chemistry, Vol. 17, pp. 208 (1925).

Safe Practices Pamphlet No. 60, "Chemical Laboratories," pp. 11 and 12, National Safety Council, Inc.

"Table of Common Hazardous Chemicals," Chemical and Engineering News, Vol. 23, No. 14 (July 25, 1945), pp. 1248-1256. Also in National Fire Codes, Flammable Liquids, Gases, Chemicals and Explosives of the National Fire Protection Association, pp. 430-459 (1945).

"Ammonia" Controlling Chemical Hazards, Series No. 1, Division of Labor Standards, U. S. Department of Labor (1945).

FUMIGANTS

Fumigation is permissible under the following conditions:

Only persons specifically authorized by the Safety Committee shall perform the fumigation.

Only fumigants specifically approved by the Safety Committee shall be used.

Appropriate on-the-spot warning signs must be posted, and the Building Superintendent, the head guard on duty, and other personnel concerned with space in which fumigation is to take place must be given advance notice.

GLASSWARE AND GLASS APPARATUS

Large glass bottles should not be put under pressure or vacuum, unless they are protected by a shield and a pressure- or a vacuum-limiting device.

Long glass tubing or apparatus should be carried vertically instead of horizontally, if possible.

Frozen glass stoppers and stopcocks should be taken to a glass worker or other experienced persons for removal. Frozen rubber stoppers or corks should be cut away from glass tubing or thermometers.

Before glass tubing is inserted in rubber tubing, rubber or cork stoppers, the ends of the glass tubing should be fire-polished or smoothed with a file and then lubricated with a little water, alcohol or glycerine. Always use toweling to protect the hands and avoid the use of excessive pressure when inserting the tubing. This precaution should also be used when removing glass tubing, even if not frozen.

Glass tubes should always extend well through a rubber stopper, since subsequent swelling of the rubber might close or partially obstruct the opening.

Large beakers should be picked up by grasping them around the outside and not by their rims. Filled or partly filled beakers of large capacity should be supported on the bottom as well as around the wall when handled.

Large beakers or flasks should not be heated by direct flame or by direct contact with a hot plate.

Large flasks should not be supported merely by a clamp around the neck, a bottom support should also be used.

Flasks should be inspected for flaws prior to their use in the distillation of flammable solvents.

Laboratory clamps of certain alloys have a low melting point and are of low tensile strength. They may fail under a combination of high stress and only moderately high temperature.

Do not seal off glass tubes containing combustible materials unless the vapor pressure in the tube has been sufficiently lowered by freezing in dry ice or a liquid-air bath. Sealed glass-reaction tubes should not be handled or opened unless they are contained in metal protecting shells and have been adequately cooled. As a further precaution, the individual opening the tubes should wear gloves and a face shield. Members of the staff who have occasion to request such service of the glass shop should keep the sealed reaction tubes cool and within metal shells until after the pressure has been released.

Stopcocks used in systems under slight pressure should be held in place by rubber bands or special clamps.

Suitable angle clamps, rather than the operator's hand covered with a towel or rag, should be used to hold a piece of glass in which a hole is being cut with a power drill. If the cutting tool sticks, it will cause the piece of glass to rotate, unless clamped in place, with possible injury to the operator's hand.

In sealing off solids, e.g., iron rods, wire, etc., in glass tubes, be sure that the solids have been degassed before making the final seal. After the seal has been made, do not heat it to a temperature higher than that used for degassing.

In performing various operations on glass apparatus, such as the freeing of frozen joints and the sealing of side tubes, a free flame should not be used **except** on clean, dry apparatus that has been flushed free of flammable vapors. Before applying the flame, the operator should satisfy himself that the apparatus is clean and dry.

Employees should immediately discard broken beakers or other glass apparatus in receptacles provided for such waste rather than leave them among other glassware to be washed. This will prevent the possibility of cuts from the washing of broken glassware.

In the handling or washing of laboratory watch glasses or other fragile glassware, avoid using pressure when attempting to remove crayon identification marks or otherwise cleaning them.

When washing microscope slides and cover slips, take care that no broken pieces are left in the sink.

VACUUM SYSTEMS

Vacuum distillations and reactions in vacuum should never be started without installation of a trap between the system and the pump. Thin-walled flasks should never be used in vacuum systems. Flat-bottomed flasks should not be used under vacuum unless made of heavy glass, used cold, and encased in a box, a metal can, or a heavy screen. Never attempt to exhaust the air from a common soda-lime or flint glass bottle.

Vessels for vacuum operation should be protected by suitable release valves.

Goggles should be worn, or safety shields should be placed in front of apparatus, when viewing vacuum distillations and similar installations at close range.

Desiccators for vacuum uses should be made of Pyrex or similar glass, and they should be protected by standard metal screens, cages, or wooden boxes.

Dewar flasks containing condensed gases should not be tightly stoppered.

In general, high-vacuum distillations should be conducted with adequate shielding. They should be cooled before venting, or vented with inert gas. Removal of air by means of water pumps must be performed with traps in the line and positive check valves to prevent water backing up into the system.

If, for any reason, the vacuum has to be broken in a system, the heat should also be interrupted to prevent excessive distillation rates on resumption of vacuum.

PRESSURE REACTIONS AND PRESSURE EQUIPMENT

No closed apparatus incapable of withstanding the maximum pressure of the laboratory's compressed-air line should ever be connected directly to the line.

Install pressure-reducing valve and adequate safety release so that the pressure can never exceed that for which the vessel is rated.

A safety valve must be installed wherever the nature of the installation would permit excessive pressures in the event that any pressure-regulating device fails to function. For example, a kettle suitable for 50 p.s.i. should never be connected through a pressure-reducing valve to the 120-pound steam line unless there is a safety valve on the kettle. Similarly, the kettle should not be connected even to a 10-pound line in which the steam is obtained by reduction of 120 pounds steam unless the 10-pound line is protected by a safety valve. It is not uncommon for pressure-regulating valves to stick in the open position or to seat improperly.

Never use cooling water in the jacket of a steam-heated vessel unless (1) the jacket will withstand maximum pressure of the cooling water, (2) the drain is open to the sewer, with no intervening valves, or (3) a safety valve is provided.

The maximum safe operating pressure should be permanently marked on each piece of equipment.

Safety valves must have proper pressure limits and capacity, and should be tested periodically.

All pressure equipment should be equipped with suitable pressure gauges. The range or total dial graduation should be about twice the working pressure. For corrosive gases and liquids or viscous fluids that would destroy a steel or bronze Bourdon tube, use a diaphragm gauge. Install coil pipe or pigtail siphon before gauge on steam connections.

In the design and installation of pressure equipment consult the applicable codes of the American Society of Mechanical Engineers and the American Petroleum Institute. Pressure vessels must pass an approved pressure test before being placed in operation. Thereafter, they must be tested or inspected by a recognized authority at least once a year.

Pressure apparatus should not be tested with oxygen.

HIGH-PRESSURE TECHNIQUE

Never fill a pressure vessel so full of liquid that external heat would develop pressures in excess of the allowable working pressure.

Never tighten a pressure joint under pressure.

Avoid even traces of oil on equipment to be exposed to oxygen under pressure. Under strong oxidizing conditions special packing or lubricants must be provided.

Escape pipes from safety-release mechanism should be arranged to discharge outside of building.

Highly hazardous operations should be handled from a distance. Gauges may be viewed through a system of mirrors. Gauges should be of the safety-back type.

All pressure vessels should be stamped plainly with the maximum allowable working pressure and the maximum allowable temperature.

When working with poisonous gases, it is desirable to have another person present. Suitable gas masks should be used. Where more than one individual works with pressure apparatus, the extent of individual responsibility should be clearly understood.

Heads of pressure vessels should be unseated before retaining devices (bolts, nuts, etc.) are removed.

Damage through failure and explosion of high-pressure vessels is not confined to direct hits by parts of the exploding bomb or autoclave and spray of autoclave contents. Secondary propelled parts are often as dangerous as the prime movers. Special safeguards, such as an armor-plate shield or a rope mat, should be installed.

Pressure tubing of small diameter should be held down rigidly along its entire length to prevent whipping in case of failure.

The following special precautions must be strictly observed:

No person, except research workers or others who are expressly authorized, may operate or interfere with any bomb apparatus or its accessories, gas compressor, catalytic apparatus, or other high-pressure equipment.

When an individual engaged in high-pressure work has reason to suspect a defect in any of the valves, cylinders, gauges, compressors, bombs, or other equipment, he must immediately have the equipment investigated and corrected, if found defective.

No high-pressure experiment or operation may be carried out or attempted unless expressly authorized by the individual in charge, and then only under his personal supervision and when he is present in the room.

No unauthorized person shall be permitted in the room while high-pressure experiments are either being prepared for or made.

The individual in charge of the high-pressure work shall be responsible for seeing that all necessary safety precautions are observed.

For further information on this subject consult "Gaseous Combustion at High Pressures," by Bone, Newitt, and Townend. (Longmans, Green and Company, Inc.).

COMPRESSED-GAS CONTAINERS

Compressed-gas containers are safe for the purposes for which they are intended. Serious accidents connected with their handling, use, and storage can almost invariably be traced to abuse or mishandling.

Cylinders should be protected against excessive rise of temperature. No part of any cylinder containing a compressed gas should ever be subjected to a temperature above 125°F, or allowed to come in contact with a direct flame.

Never store cylinders near highly flammable substances such as oil, gasoline, or waste.

Do not store cylinders near elevators or gangways, or in other locations where heavy moving objects may strike or fall on them. Horizontal storage should also be avoided.

Valves and safety plugs should always be protected with a cap when cylinders are being transported.

Cylinders should not be used without being secured to some solid support. In the laboratory a steel strap around the cylinder may be fastened to a simple C-clamp which is easily attached to the bench top. A cylinder can also be supported by means of a standard non-tipping base.

Cylinder valves should be kept closed when not in use. When opening a valve, open it slowly. Never hammer the valve wheel in attempting to open or close the valve.

A simple needle valve that is not completely shut off is capable, in time, of transmitting the full pressure of the cylinder to apparatus connected to such a valve. This applies also to single- and double-stage reduction valves that are not in proper working order. The proper precaution is a safety release valve or device in the system to which pressure is being applied. If practicable, cylinders should be disconnected from the rest of the apparatus at the close of each day.

Accurate regulation of low rates of gas flow from a high-pressure source should not be attempted with a simple needle valve--use a pressure reducing valve.

Pressure-reducing valves that fit cylinders of water-pumped nitrogen or oxygen must never be used on oil-pumped nitrogen. Oil may enter the valve rendering it unsafe for future attachment to an oxygen cylinder. Any adapters that might permit inadvertent use of these regulators on oil-pumped nitrogen should be discarded.

Gauges used on oxygen tanks are subject to two types of explosions: (a) simple mechanical breakage under pressure of the Bourdon tube within the gauge, and (b) actual explosion of oxygen-oil mixtures within the gauge tube. All small gauges (3 inches or less) used on high-pressure oxygen should be examined as to their age and design, and replaced by new safety-back gauges if they are not provided with this feature. All gauges used with high-pressure oxygen should bear the following warning in a conspicuous place: "Oxygen--Use no Oil."

Also consult the pamphlet, "Safe Handling of Compressed Gases," by the Compressed Gas Manufacturers' Association, Inc., for detailed information on the safe handling of compressed gases.

FLAMMABLE MATERIALS

General regulations concerning the storage and handling of flammable liquids are covered by the sixth paragraph of Bureau Memorandum No. 275, dated January 13, 1942, revised under date of July 30, 1945, which reads as follows:

"Not more than two days' supply limited to total of 10 gallons of flammable liquids which are used intermittently or only occasionally, should be stored in any one room at any one time. Any exceptions involving larger quantities of flammable liquids must be approved by the Safety Committee of the Laboratory with concurrence by the Chief of the Bureau. All flammable liquids should be stored in tightly-sealed containers and exposure of the liquids or their vapors to the atmosphere never should occur in the presence of flame, sparks, or hot surfaces, such as electric heating elements in operation."

Safety cans should be used wherever possible for flammable liquids.

Ordinary household electric refrigerators are not adapted to the storage of volatile, flammable solvents owing to the possible ignition of the vapors by the arcing of motor or lamp switches within the box. Unless refrigerators have been properly rewired or altered to eliminate this hazard, volatile, flammable solvents, even in very small quantities, must not be placed in them.

In distilling or refluxing volatile, flammable liquids a water or steam bath should be used rather than a free flame or a hot plate. "Glas-Col" heating mantles or similar systems are also particularly advantageous. Where practical, distillation should be conducted in a hood. Careful attention should be given to operation of the heating appliance at the proper temperature and to adequate cooling of the condenser. The flask should be set up in an empty container, or in a tray containing sand, capable of confining all of the liquid in case the vessel fails. Distillation equipment in operation should not be left unattended.

Vacuum distillations in flasks of more than 500 ml. should be carried out behind a safety shield or safety glass to protect not only the operator but also others in the vicinity in case the flask collapses. Goggles protect only the wearer.

No open flames should be allowed where flammable gases, vapors, or dusts are present. Gases or vapors heavier than air will seek the lowest level and may float along bench and table tops or the floor for considerable distances. Sources of ignition many feet away, therefore, may cause an explosion or fire. Conspicuous signs warning against smoking and the use of open flames should be displayed prominently.

Do not keep even small bottles of volatile, flammable liquids in the sunshine or where heat from a hot plate, burner, or other devices may cause the stopper to blow out and release vapors.

Flame arrestors should be installed in vent or vacuum lines connected to processing equipment containing flammable liquids.

Safety valves must always be vented to the outside if there is a possibility of their discharging flammable gases or liquids.

Gauge-glass valves should be of the automatic self-closing type.

Electrical wiring and apparatus for use in hazardous locations should be of the type approved for such locations. (See Article 500, "Hazardous Locations", of the National Electrical Code).

Be sure that no electrical apparatus employing a device which may produce sparks, such as an open relay, is operated where flammable vapors are present. Electric Refrigerators equipped with outside relays are typical examples.

The electric breaker switch with which some motors are provided may also be a source of ignition of flammable vapors. Motors so equipped should not be operated where such vapors are present. For stirring volatile solvents use explosion-proof electric motors or motors operated with air or water under pressure.

In areas where flammable gases, vapors, or dusts may be present, non-sparking tools should be used. Power transmission for equipment should be of the type that will not produce sparking or build up electrostatic charges.

The exposed, non-current-carrying metal parts of equipment used in hazardous locations should be grounded in accordance with the requirements of Article 250, "Grounding" of the National Electrical Code.

Where unstable substances capable of exploding are dried in electric ovens, all rigid door latches should be removed and the oven surrounded by a suitable protective cage. However, solids containing even small amounts of volatile, flammable liquids should not be dried in electric ovens with exposed heating coils or switch contacts.

Do not solder or use open flames on pipes or vessels which have contained flammable materials unless all of the flammable material has been removed and the pipes or vessels have been cleaned thoroughly. If possible, have them filled with water while the work is being performed.

Provide exhaust systems to remove fumes, dusts, etc.

Where flammable gases may be present, use steam instead of compressed air to clean machinery.

Valves and pipes carrying flammable materials should be prominently identified. (See National Safety Council, Safe Practices Pamphlet No. 88, "Identification of Piping Systems").

oil, rags or waste should be placed in metal containers with close fitting covers. Containers must be emptied and contents properly disposed of at the end of each day.

For detailed information on the properties of flammable liquids consult "Fire Hazard Properties of Flammable Liquids", National Fire Codes, Flammable Liquids, Gases, Chemicals and Explosives, National Fire Protection Association, pp. 461-514, (1945).

ELECTRICAL INSTALLATIONS

Electrical wiring and equipment for use in hazardous locations should comply with the requirements of Article 500 "Hazardous Locations," of the National Electrical Code. (It is suggested that the electrician be consulted before ordering electrical equipment.)

All electrical alterations and repairs should be made by the electrical shop. In case of necessity, however, qualified laboratory workers may perform minor electrical jobs, provided they are authorized to do so, and such work is inspected by the electrical shop.

Temporary electrical installations which may be necessary to expedite important research should be made only by an electrician. If it is found later that electrical service is required for an extended period, the temporary installations should be replaced by approved fixtures and appliances as soon as possible. Temporary installations definitely made for a short period of time should be dismantled and discarded just as soon as the need for them has passed.

For the protection of personnel, the work areas, such as laboratory benches and hoods, are served by a three-wire electrical distribution system, the third wire of which provides a protective ground. All equipment served by these outlets should utilize this safety feature.

The use of extension cords should be kept at a minimum. Such cords should be of the approved type and as short as possible, and they should not be used as substitutes for permanent or fixed wiring.

Care should be exercised not to overload electric motors, Variacs, and Variatrans.

Do not fasten or block the throw of circuit breakers.

Check the demand on work-bench and hood circuits before adding any large load.

A cut-off switch in the input to high-voltage and machinery circuits should be provided and used.

PROCESS EQUIPMENT

Gauge-glass valves should ordinarily be of the automatic, self-closing type.

Keep hands out of moving conveyors. Means for feeding machines must not endanger the limbs of operators.

Take care that loose neck ties, clothing, coveralls, and hair do not catch in moving machinery.

Where practical, use color codes and prominent labels on all pipe lines.

Do not lubricate exposed parts of machinery while they are moving.

Do not enter tanks without providing a fresh air supply; also have another person nearby to aid in case of an emergency.

Do not enter a large tank or vessel equipped with an agitator unless the main switch is open and another person is near to prevent starting of the agitator.

If jackets or coils are arranged for alternate steam-heating and water cooling, constant care is necessary to avoid entry of untreated water into the condensate return lines. A warning sign should be installed.

In processing vessels heated by direct admission of steam, condensate must be run into the sewer- never into the condensate return lines.

Never open or close any valve or switch without informing all users of the service.

Do not take the word of the previous operator that all valves, pumps, etc., are properly adjusted; check them yourself. Do not leave your shift without thoroughly acquainting your successor with all of the unusual conditions that prevail.

Avoid the use of 3-way valves if two ordinary valves will serve the purpose. Three-way valves often cause confusion and may be turned the wrong way in an emergency.

Automatic valves must be provided which will shut off fuel burners when the supply fails.

Steam pipes and other hot lines near working levels must be insulated to prevent burns.

Pressure must be removed from pipe lines and vessels before repairs or alterations are made.

MISCELLANEOUS LABORATORY AND PILOT PLANT TECHNIQUE

Ball mill grinding is hazardous if iron balls are used in the presence of aqueous liquids because appreciable hydrogen pressure may develop.

Before a centrifuge is operated for the first time, care should be exercised to follow the manufacturer's instructions and to properly secure the basket or head in position. When a centrifuge is provided with a housing having a lid, it should not be operated with the lid open or unlocked. A centrifuge that does not have a protective, stationary housing should not be used without a suitable safeguard to protect the operator.

Be careful that sudden vaporization of liquid does not occur because of superheating. Never add a boiling stone or similar device to liquid after heating has begun.

Bottles or other containers made of flint or soda-lime glass cannot be heated or chilled rapidly without cracking or breaking. Only "Pyrex" or similar glassware should be used under such conditions.

Be sure that condenser water has been turned on and remains turned on when using volatile, flammable solvents in Abderhalden dryers and distillation apparatus. Make certain that the cooling water is at a sufficiently low temperature.

Never conduct operations over a grating, if spilled material could cause injury to someone below.

A wet place on the floor may be the result of an overhead spill; therefore, do not look directly upward.

Drinking fountains should be used in preference to drinking from beakers or other laboratory utensils.

Poisonous or corrosive liquids should be pipetted and siphoned by means of mechanical suction, not by the mouth.

Geissler potash tubes should be filled or emptied by mechanical suction or air pressure and not by sucking or blowing with the mouth.

Individual wash bottles or bottles equipped with rubber bulbs should be used in order to prevent the spread of colds or other infections.

Do not stand on boxes or swivel stools to work. Use suitable ladders or platforms.

Exposed, non-current-carrying metal parts of fixed and portable equipment, which are liable to become electrically energized, should be grounded in accordance with the requirements of Article 250, "Grounding", of the National Electrical Code.

Charges of static electricity may be generated when liquids that are poor conductors are transferred from one container to another and when compressed flammable gases are released rapidly from a cylinder. If these charges build up to a sufficiently high voltage, they jump across air gaps, forming sparks which may ignite flammable gases or vapors. This hazard can be controlled by connecting electrically the container and the receiver and grounding the system.

Provide handrails on stairs and platforms. Platforms above shoulder height should be equipped with toeboards.

Illumination should be adequate everywhere.

Escaping gas should be reported to your supervisor if its source cannot readily be determined. Unsafe conditions, operations, or equipment should also be reported to him.

Turn off a gas burner by means of the cock on the service outlet, not by turning off the cock at the base of the burner.

Electrical heating appliances, such as hot plates, must be turned off at the close of the working day.

MECHANICAL AND SHOP EQUIPMENT

General Precautions

No person should operate any machine in the mechanical shops or other locations without permission of his supervisor and the man in charge of the machine.

Interrupting a workman who is busy on a power-driven machine, such as a lathe, drill, milling machine, or pipe-threading machine, may cause him to have an accident. The safe thing to do is to wait until he is free or to see his supervisor.

While only one starting button should be provided for each machine, several auxiliary or safety stops may be advisable so that the machine can be conveniently shut down by fellow workers in case of accident to the operator.

Where possible, safeguards should be provided for each point of operation to prevent injury to the operator from dangerous moving parts or from the moving material. This may be accomplished by using one or more of the following devices:

MECHANICAL FEEDING DEVICE.

HAND CONTROL DEVICE LOCATED AT A SAFE DISTANCE FROM THE POINT OF OPERATION.

TOOL SO DESIGNED THAT IT IS IMPOSSIBLE FOR THE OPERATOR TO GET IN THE DANGER ZONE.

DEVICE THAT INTERRUPTS THE MOVEMENT OF THE TOOL OR MACHINE WHILE ANY PART OF OPERATOR'S BODY IS IN THE DANGER ZONE.

DEVICE THAT PULLS OR PUSHES THE OPERATOR'S HANDS AWAY FROM THE DANGER ZONE.

BARRICADE, COVER, GUARD OR ENCLOSURE.

Machines should not be allowed to run unattended. Shut off the power immediately after finishing a job. Someone else may be injured by a machine that is running when he has reason to think it is not.

Never use the hands or feet for braking machines.

Operators of machines in which clothing may become entangled should wear snugly-fitting, short-sleeved shirts or jackets and no neckties. Neckties offer a serious hazard, as do rings and wrist watches. Rolled-up sleeves are caught very easily and may be a serious hazard because of the large amount of cloth bunched in a roll. The use of gloves should be avoided.

Floors should be kept in good condition and free from chips or obstructions. Slippery floors around machines are especially hazardous.

Exhaust systems should be provided for collecting vapors, fumes, and objectionable dusts at their sources and discharging them outside of the building.

Spray painting should be done only in properly designed spray booths, preferably of the water type, or in large spaces, well ventilated.

Exposed belts and pulleys, gears, projecting parts, shaft ends, clutches, and other moving parts present definite accident hazards. Suitable guards should be provided; they can be designed and applied best by the machine builder.

Chip guards (shields) should be available for use on lathes, shapers, and other machines when needed. Also, goggles should be worn when needed. The shields are particularly desirable when brass, cast iron, or tool steel is being machined because chips are most likely to fly from these metals.

Safe Practices for Specific Machines

LATHES. - Safety lathe dogs, such as those having countersunk set screws, should be used rather than lathe dogs with protruding set screws.

Whenever chucks or face-plates are changed, they should be started on the spindle by hand power, never by machine power.

See that the work is counter-bored to sufficient depth to prevent it from being torn loose.

Be sure that the lathe spindle fits its bearings and that the carriage is not loose on the ways.

Do not attempt to change or adjust machine tools while the lathe is in motion.

Pipe guards should be installed to prevent a fellow worker from becoming caught on the projecting revolving stock.

DRILL PRESSES. - Never attempt to hold the work by hand when using the drill. Make it secure with a clamp.

Avoid forcing or feeding the drill too fast. Broken or splintered drills have caused serious injuries.

Fingers, cotton waste or rags must not be used to brush chips away from the drill; use a stick or brush.

Never use gloves in operating a drill press except when handling rough materials and then only when the drill is not running.

Keep your hair away from the drill or drill spindle. Wear a cap or keep your hair cut short.

Be careful how you reach around the revolving drill. Keep your sleeves short or they may catch on it.

MILLING MACHINES. - When setting up jobs or making adjustments, never fail to stop the cutting tools.

Make sure that cutter and arbor are secure.

See that the work is clamped securely.

Avoid cuts and other possible injuries by using a brush to remove chips.

Be careful about your clothing; loose garments are easily caught in machinery.

Keep the floor around the machine clean and free from objects that might cause a fall.

HACK SAWS (Power). - Hack saws should be so located that the end of the material being cut does not protrude into a passageway.

Be sure that the material is clamped securely and that the piece being cut off will not fall where it may injure someone.

ABRASIVE WHEELS. - Abrasive wheels are fragile and present exceptional hazards if abused either in handling or operation. Breaking of the wheel and accidental contact with the wheel while it is in motion are the principal causes of injuries.

Care should be taken to see that wheels are properly mounted and equipped with suitable guards. All wheels should be given the "ring" test before they are mounted. After a wheel has been mounted, it should be allowed to develop its rated operating speed for at least one minute, during which time the operator should stand aside and out of danger. Wheels should not be operated above normal or specified speed.

The operator should wear goggles.

When using sanders, wear goggles, and be sure that the work is held securely in place on the bed. Do not try to sand pieces that are too small to be handled safely. Be especially careful when sanding round pieces.

OXYGEN-ACETYLENE WELDING AND CUTTING. - Oxyacetylene apparatus should be operated only by properly trained and instructed persons.

No torch should be used outside of regularly authorized welding areas, unless the proper equipment, shields, or booths are used, and an attendant is present to protect the hose and to guard against fire. There are some locations, such as near explosive gases or flammable liquids, where welding or cutting must **never** be permitted, regardless of the precautions taken.

Keep flames, sparks, molten slag, and hot metal from coming in contact with combustible materials.

Before cutting or welding in a new location for the first time, always check with the nearest foreman or person in authority. He may know of some serious explosion or fire hazard with which you are not familiar.

Do not cut or weld pipes or vessels which have contained flammable materials unless all of the flammable material has been removed and the pipes or vessels have been cleaned **thoroughly**. If possible, have them purged with steam or an inert gas, or filled with water while the work is being performed.

Cutting or welding work which can be moved should be taken to a location where there will be no possibility of setting fires.

Materials that burn easily should be removed to a safe distance if possible.

Use sheet-metal guards, asbestos paper or curtains, or other protection to confine sparks within the working area.

Always guard the oxygen and acetylene hose from chance of injury on the job.

Use the correct oxygen pressure when cutting.

All gauges used with oxygen should bear the following warning in a conspicuous place: "Oxygen--Use no Oil".

Do not store extra cylinders of gas within the working area.

Be prepared to put out a fire by having one or more fire extinguishers ready for instant use.

Areas in which cutting or welding is being done should be well ventilated.

For information regarding the safe handling of oxygen and acetylene cylinders, see bulletin entitled "Safe Handling of Compressed Gases," issued by the Compressed Gas Manufacturers' Association, Inc.

COMPRESSED AIR. - Many hazards arise from improperly installing, maintaining, and operating compressed-air equipment. Fatal accidents or serious injuries may result from explosions in air compressors and receivers, and also by the introduction of compressed air into the eyes, ears, or other openings of the body. Compressed air, when misused, can be extremely dangerous. Under no circumstances should a worker aim an air hose at anyone. Air under pressure will pass through clothing, and serious injury is possible. Its use for cleaning clothing, therefore, should be energetically discouraged.

For information on this subject, see Safe Practices Pamphlet No. 47, "Compressed Air Machinery and Equipment," of the National Safety Council, Inc.

JOINTERS. - Be sure that the cutters are in good condition, sharpened, and securely held on the arbor.

Do not use jointer on pieces of wood less than 12 inches long.

When working on plywood, joint only the edges.

POWER SAWS--BAND, BENCH AND SWING. - Be sure that the saw is not defective and that it is firmly held in place.

Saws should be equipped with proper guards.

While being sawed, material should be held firmly against the gage with the hands at a safe distance from the saw.

When short pieces are sawed, the stock should not be fed with the fingers. A stick of hard wood made for that purpose should be used.

Never place the hands back of the saw or pull the work through from the back.

When using the rip saw, do not try to rip a piece that is too narrow.

Do not allow wood scrap to accumulate on the machine bed.

Care of Machines

All machinery should be kept in good repair. Failure of a machine to run properly should be reported immediately to the foreman. Repairs or adjustments should not be made while machinery is in operation. The repairman should make sure that power cannot be turned on without his knowledge and permission.

All machines should be cleaned and oiled and their condition checked at regular intervals. Exposed parts of machinery should not be lubricated while they are in operation.

Care of Tools

The use of tools of poor quality or in poor condition is hazardous. Never use a tool with a faulty handle or a cold chisel, chisel bar, cutter, or other tool with a mushroomed head. Such heads can readily be corrected by grinding.

Keep the jaws of all wrenches in good condition, and caution workers against misusing them.

Keep sharp-edged tools sharp. This will eliminate strains and slips. The edges should be protected while the tools are in storage.

Portable electric tools and pneumatic tools should be kept in perfect working condition. Special attention should be given to the cable and hose connections and to the control valves and switches.

Handling Material

Sharp edges and burrs on iron and steel stocks and splintered edges of lumber stocks may cause painful scratches and cuts. The use of hand-leathers and gloves in handling material will prevent many injuries of this nature.

When material is heavy or bulky, obtain help in handling or moving it. Select one individual to supervise or direct operations and abide by his instructions.

Metal and lumber stocks should be kept in racks provided for that purpose. They should not be allowed to lie scattered on the floor or to project into aisles or passageways where they may cause injury.

See also Safe Practices Pamphlet No. 39, "Machine Shops," National Safety Council, Inc.

HOISTING AND MOVING OF EQUIPMENT

The hoisting and moving of heavy equipment should be done only when supervised by a qualified individual. The lack of proper supervision or the presence of too many bosses may cause a serious accident.

The use of cranes must be restricted to designated individuals who are fully qualified to operate such equipment and who will be responsible for their proper use. One of the chief dangers of using cranes is in improperly securing the load to be moved. When a large traveling crane is not in use, the central chain must be secured to a vertical column and the lifting assembly must be left at least eight feet above the floor. No one should be permitted to ride on the load or the hook.

When installing heavy apparatus, make ample provision for future dismantling when repairs will be required. Provide lifting hooks and supports for heavy parts that must be removed. Before installing heavy equipment consult the Building Superintendent regarding possible overloading of floors.

Do not overload chain falls, blocks and tackles, ropes, etc. Know the load limits.

Do not stand beneath loads being lifted.

Limit loads lifted by hand and learn to lift the right way to avoid body strain. Bend your knees; keep your body erect; keep your mouth open; then push upward evenly and gradually with your leg muscles.

Do not use a ladder that is defective or insecurely supported. When a ladder is placed in position, the horizontal distance from the top support to the foot of the ladder should be at least one fourth of the length of the

ladder. Ladders for use on smooth surfaces should be equipped with safety shoes. Only one person should be on a ladder at one time. Ladders must not be placed in front of doors opening toward them unless the doors are blocked open, locked, or guarded.

HOUSEKEEPING

Keep the plant clean; do not allow trash or dust to accumulate.

Receptacles should be supplied for waste materials. Oily rags and other combustible wastes should be placed in metal containers with close-fitting covers.

Passageways and exits should be kept clear of obstructions.

Lumber with protruding nails should not be left on the floor. All discarded material should be picked up.

Never leave tools on a ladder.

Openings in the floor, such as those caused by temporary removal of gratings and drain covers, should be provided with guards.

Do not leave broken glass in towels.

OFFICE AND MISCELLANEOUS HAZARDS

Do not stand on chairs or stools.

Tilting chairs while occupying them may result in a bad fall.

Not more than one drawer of a filing cabinet should be pulled out at any one time. Two heavily loaded upper drawers out at the same time may cause the cabinet to become top heavy and overturn. Desk and filing cabinet drawers should not be left standing open.

Stiff paper, if not handled carefully, may cause serious cuts.

Cigarette and cigar stubs, pipe ashes, and matches should not be discarded into waste-paper baskets; use the ash trays provided for this purpose.

Floors made slippery by spilled material or high polishing are hazardous and should be avoided.

Running up and down stairs or in corridors is dangerous to one's self and to others who may not be able to get out of the way; it should not be done.

There is a collision hazard at every blind corner.

Corridors should be well lighted.

Drive carefully when operating automobiles and trucks; observe all traffic regulations. Pedestrians should be cautious and on the alert when crossing streets, especially those not provided with traffic lights.

PROTECTIVE EQUIPMENT FOR PERSONNEL

Employees handling acids or other corrosive substances should wear rubber gloves, chemical workers' goggles and aprons.

Safety goggles should also be worn by other employees engaged in work which may result in injury to the eyes. The proper type of goggles should be used for the particular hazard involved, such as impact, dust, splash, glare, or injurious light rays.

Employees whose duties do or may bring them in contact with an atmosphere deficient in oxygen or with poisonous or irritating gases, fumes, vapors, or dusts should wear respirators, gas masks, or other protective breathing equipment approved by the United States Bureau of Mines. A gas mask is not protection against an atmosphere deficient in oxygen. In such situations ventilation or a hose mask having an air or oxygen supply is required.

Protective equipment should be readily available and should be maintained properly. Employees should be trained in its proper use.

Adequate warning signs should be displayed prominently to indicate the nature of the precautions necessary around hazardous work.

Safety shields constructed of shatter-proof glass or heavy wire screening should be placed around all equipment where there is a possibility of rupture or shattering of the apparatus. These enclosures should be used even though the operator is wearing goggles or a face shield, since there is always the chance that persons working near him, and not so protected, will be injured.

MARCH 1946